Application of two-dimensional detection based on the background subtraction in badminton Hawkeye system

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Abstract. With the development of computer technology, computer vision technology was getting more mature. The two-dimensional detection in the badminton Hawkeye system was studied with background subtraction. The mass center coordinates of the badminton were obtained after eliminating the influence of the isolated noise by morphological opening operation, which have found the base of badminton 3D information obtaining and reconstruction for the following research.

Introduction

The two-dimensional detection is one of the most important steps of the badminton Hawkeye system. The mass center coordinates of the badminton obtained by detection are the premise and foundation for three-dimension reconstruction and judging the placement of the badminton.

The background subtraction is used in this paper to detect the two-dimensional information of the badminton Hawkeye system. The background subtraction has been developed advanced in the recent years. For example, Haritaoglu[1]thought that the pixel of the image could be analysis and counted by the maximum time subtraction, the maximum and minimum strength. The analysis model of the data was established and the background was updated. The self-adaptive background model was built with Kalman filtering to test the change of the light by Karmann[2]. The change of the light and the interference of the moving background to the image was analyzed with self-adaption Gauss background model by Grimson &Stauffer[3-4].

Process of two-dimensional detection

The process of the background subtraction of the badminton Hawkeye system can be divided into the following steps. Firstly, turn on the cameras to take the first frame as the background image. The binary image is obtained after differencing the next images and the background image. Secondly, the number of the characteristic points are statistics, and a counter is set to statistic the number of the changing characteristic points. Thirdly, two threshold are set. One is for division, the counter plus 1 when the absolute value of the difference of the pixel. Another one is for compare with the counter. When the value of the counter is larger than this threshold, it can be confirmed that there's moving object in the image. Last, the differenced images are saved and the mass center are calculated.

Noise processing

The background subtraction is easily influenced by noise and mutation factor because it only concern about the single pixel, which will distort the detected results. The light in the match is the key factor of detecting and locating. The mathematical morphology is used to eliminate the isolated

noise of the images.

The basic way of the arithmetic of mathematical morphology is divided into expansion operation and corrosionoperation. Corrosion operation can be expressed by:

$$E = X \odot B = \{(x, y) \mid \hat{B}_{x,y} \subseteq X\} \tag{1}$$

Where X is defined as the image value after binaryzation; B is defined as the element after corrosion; the output is E, which is also a binaryzation value.

Expansion operation is just contrary to corrosion operation. The empty pixel are filled after image segmentation, which makes the image more full. The expression can be showed as:

$$D = X \oplus B = \left\{ (x, y) \left[\left[\hat{B}_{x,y} \cap X \subseteq X \right] \right] \right\} \tag{2}$$

Where X is defined as the image value after binaryzation; B is defined as the element after corrosion; the output is D after expansion operation.

Morphological opening operation refers to corrode the image to eliminate the isolated noise and then expand it to separate the object from the boundary, which makes the boundary smooth and it will fill the empty pixel after corrosion operation. The morphological opening operation could be expressed as :

$$X \circ B = (X \odot B) \oplus B \tag{3}$$ Where X is defined as the image value after binaryzation; B is defined as the element after morphological opening operation.

Results and analysis

The background subtraction is used to detect the moving badminton in the badminton Hawkeye system. And then the morphological opening operation is used to smooth the images. The fig.1 shows the results of the experiment.
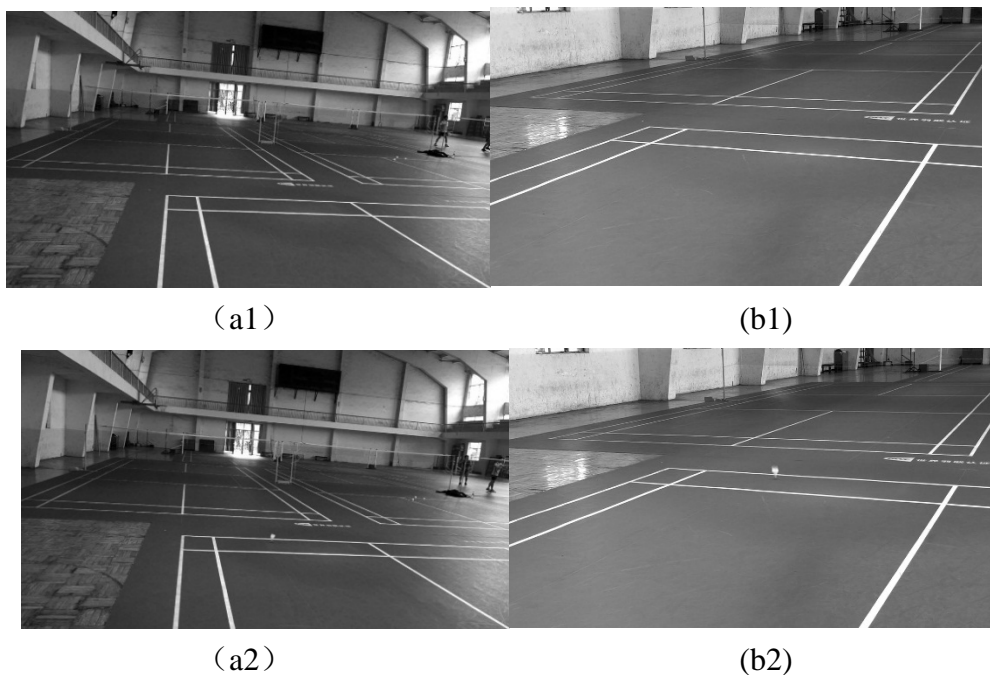

（a1）   (b1)

（a2）   (b2)

（a3）   （b3）

Fig.1 The results of Location

Where (a1)(b1) are the background images of the left and right camera in the badminton Hawkeye system;（a2）（b2）are the images filmed the moving object(badminton);（a3）(b3) are the images after segmentation. The cross center marked in the image is the mass center of the badminton. The left and right camera could film 8-10 sets images and fig.2 is just one set of them. The mass center of the badminton is showed in table 1.

Table1 Mass center of the badminton

NO.	Left image		Right image	
	X coordinate	Y coordinate	X coordinate	Y coordinate
1	720	621	1200	800
2	691	562	541	606
3	665	502	553	576
4	655	471	567	544
5	594	384	581	530
6	574	352	592	499
7	556	324	611	467
8	537	298	624	434
9	504	254	633	401
10	474	221	649	369
11	448	194	665	336
12	441	168	681	310
13	445	152	695	285
14	453	131	708	260
15	465	94	724	233

The first set data in table 1 includes the point(1200，800). But the size of the image is 1080× 650, which we consider that there's no object in the image. In the procession of calculation, the next set data will be read to calculate the three-dimensional information.

According to the previous discussion, the background subtraction and supplemented by morphological opening operation is used to detect the two-dimensional information. The mass center of the badminton in fight is obtained, which have found the base of badminton three-dimensional information obtaining and reconstruction for the following research.

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